ARMORED FORCE
MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

PROJECT NO. 3 - TOXIC GASES IN ARMORED VEHICLES

Final Report On

Sub-Project No. 3-15 - Determination of the Characteristics and Effects Upon the Crew of Gun Fumes from Firing of the Weapons in the M4A4E1 Tank

Project No. 3-15

April 29, 1943

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1. PROJECT: No. 3 - Toxic Gases in Armored Vehicles. Final Report on: Sub-Project No. 3-15, Determination of the Characteristics and Effects Upon the Crew of Gun Fumes from Firing of the Weapons in the M4A4E1 Tank.

a. Authority - Letter, Commanding General, Headquarters Armored Force, Fort Knox, Kentucky, 400.112/6 GNOHD, dated September 24, 1942.

b. Purpose - To determine the extent of the hazard from fumes released by firing of the weapons in the M4A4E1 tank with 105mm howitzer.

2. DISCUSSION:

a. Methods and Conditions of Test.

(1) Fire Pattern:

(a) 105mm Howitzer: The piece was fired at the rate of one (1) round every 10 seconds in bursts of 5. Three such bursts were fired at 5 minute intervals. Total, 15 rounds.

(b) Machine Guns: The bow machine gun was not fired since the piece and mounting are the same as in other tanks of the M4 series, previously reported (See Report on Sub-project 3-1, 3-5, February 15, 1943). Three belts of 100 rounds each were fired from the turret machine gun in a total of 8 minutes. Each belt was expended in approximately two minutes.

(2) Ammunition: 105 mm; ammunition 50-50, shell M1; machine gun, caliber .30 ball.

(3) Tank Operation: Tank buttoned-up and motor running at normal idling speed. Full crew in tank. Wind, 6 mph quartering 150°.

(4) Analysis: Air samples were analyzed for carbon monoxide and ammonia; bloods taken from the crew members before and after firing were analyzed for carbon monoxide hemoglobin. Details of the analytical procedures may be found in the report on Sub-projects No. 3-1, 3-5, February 15, 1943. Results of the present test are presented in the Appendix.

3. CONCLUSIONS:

a. 105mm Howitzer:

(1) Of the crew, the loader is exposed to the highest carbon monoxide concentration (0.11%). The blood of the loader showed an increase of 14.6% carbon monoxide hemoglobin during the firing of 15 rounds.

(2) The other turret crew members encounter lower concentrations of carbon monoxide, while exposure of the men in the bow is negligible.

(3) Irritation of the eyes and nose was experienced by the loader with ammonia concentrations of 165 and 290 ppm.

(4) There was no accumulation of carbon monoxide or fumes from one burst to another.

(5) Under the conditions of these tests atmospheric conditions in the turret were not satisfactory. The efficiency of the crew was impaired by the ammonia and other irritating fumes and a definite hazard from carbon monoxide was present. More effective turret ventilation is needed.

b. Turret Machine Gun:

(1) The average concentration of carbon monoxide exceeded 0.2% at all turret crew positions during the firing of the turret machine gun. At the loader's position the concentration was above 0.3%.

(2) Although the test lasted only 8 minutes (being terminated then because of danger to the crew) and only 300 rounds were fired, high concentrations of carbon monoxide were found in the blood of the turret crew members, the increase ranging from 11 to 15% during the test.

(3) Ammonia and other fumes built up to such high levels in the turret during firing that the turret crew members were unable to execute their normal tasks effectively.

(4) The serious problem presented by the turret machine gun results from the manner of mounting the gun with its muzzle some distance back of the mantlet. As a result, noxious gases escaping from the muzzle as well as from the breech are drawn into the turret.

4. RECOMMENDATIONS:

a. 105 mm Howitzer.

(1) That independent exhaust ventilation be provided in the turret for the control of fumes from the 105mm howitzer. (See Report on Control of Gun Fumes in M4 Series Medium Tanks, Sub-Projects No. 3-1, 3-5, Feb. 15, 1943).

(2) That the turret machine gun be mounted in such a manner as to prevent entry of fumes from the gun muzzle into the turret.

Prepared by:

Captain Norton Nelson, SnC
Captain Steven M. Horvath, SnC
Captain Ludwig Eichna, MC
Lieutenant Robert Walpole, SnC

APPROVED Willard Machle
WILLARD MACHLE,
Colonel, Medical Corps,
Commanding.

3 Incl.
#1 - Appendix 1
#2 - Tables 1, 2, & 3
#3 - Fig. 1, & 2

APPENDIX 1

Results

1. 105mm Howitzer:

The problem of gun fumes from the 105mm howitzer is of the same order of magnitude as from the 75mm gun in the standard M4A4 tank, in spite of the fact that a greater quantity of toxic gas is produced by the larger piece (Table 1 and Fig. 1). Offsetting the higher CO production is an increased air movement through the turret resulting from the less tightly fitting gun mount. Evidence of better ventilation is seen in the more rapid clearance rate in the M4A4E1; 12 seconds (Table 1) as compared with 50 seconds in standard M4A4.

The greater work entailed in loading the heavier ammunition makes the situation of the loader somewhat more serious in the case of the subject tank than when operating the 75mm piece. The increased lung ventilation resulting from the higher work rate leads to more rapid accumulation of carbon monoxide in the blood. Thus, in a 15 minute exposure the CO hemoglobin increased to 14.6% (Table 3) whereas in the standard M4A4 the blood concentration was only 22% after 30 minute exposure to approximately the same atmospheric concentration of CO.

2. Turret Machine Gun:

Conditions were so severe during firing of the turret machine gun that the trial was stopped after only 300 rounds had been fired. It is estimated from the blood concentrations of carbon monoxide (Table 3) that had the standard test (1000 rds) been completed serious carbon monoxide poisoning, and possibly unconsciousness, would have resulted. The high blood carbon monoxide content reflects the extreme atmospheric concentrations to which the crew were exposed (Table 2 and Figure 2)

The highly hazardous situation presented by this weapon results from the trapping of muzzle fumes directly behind the mantlet and subsequent collection in the turret. The gun muzzle is practically within the turret; the barrel terminates some distance behind the mantlet and the turret opening through which it passes is large. Thus, a considerable portion of the muzzle fumes are drawn into the turret with the inflowing air. It is doubtful if the difficulty can be corrected by increased ventilation. The gun should be remounted so as to extend through the mantlet or a large enough opening provided in the shield to insure outward escape of the muzzle gases.

TABLE 1

CONCENTRATIONS OF CARBON MONOXIDE AND AMMONIA
From 105mm Howitzer

	Peak Concentrations at End of Burst	
	Carbon Monoxide, Percent	Ammonia, p.p.m
After 2nd Burst After 3rd Burst	0.433 0.277	290 165
	Aver. Concentration by Cont. Sampling	
Loader Commander Gunner	0.110 0.064 0.037	
Clearance Rate after 2nd burst (Time for Conc. to decrease 50%)	12 seconds	

TABLE 2

CONCENTRATIONS OF CARBON MONOXIDE AND AMMONIA
From Turret Machine Gun

	Peak Concentrations at End of Belt	
	Carbon Monoxide, Percent	Ammonia, p.p.m
During 1st Belt During 3rd Belt	0.466 0.376	180 110
	Aver. Concentration by Cont. Sampling	
Loader Commander Gunner	0.336 0.244 0.218	

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TABLE 3

CARBON MONOXIDE CONCENTRATIONS
IN BLOOD OF CREW MEMBERS

CREW MEMBER	CO Hemoglobin as % of Total Pigment		
	Before Exposure	After Exposure	Increase
105 mm Howitzer *			
Loader	1.9	16.5	14.6
Commander	1.1	3.0	1.9
Gunner	0.0	5.0	5.0
Driver	3.4	4.0	0.6
Asst. Driver	4.2	4.8	0.6
Turret M. G. **			
Loader	0.2	15.3	15.1
Commander	0.9	13.2	12.3
Gunner	0.2	11.6	11.4
Driver	-	5.0	-
Asst. Driver	-	1.8	-

* 15 Minute Exposure
** 8 Minute Exposure

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FIG. 1

CARBON MONOXIDE CONCENTRATION FROM 105 MM HOWITZER

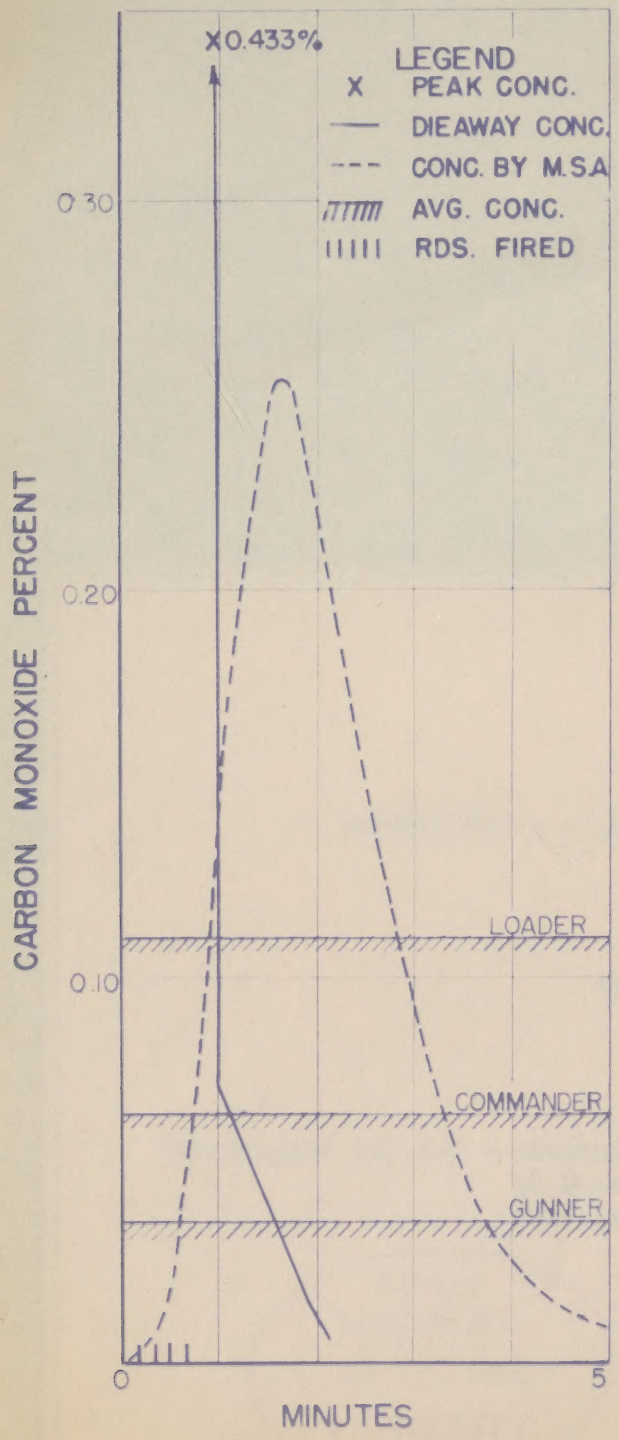

FIG. 2

CARBON MONOXIDE CONCENTRATION FROM THE TURRET MACHINE GUN

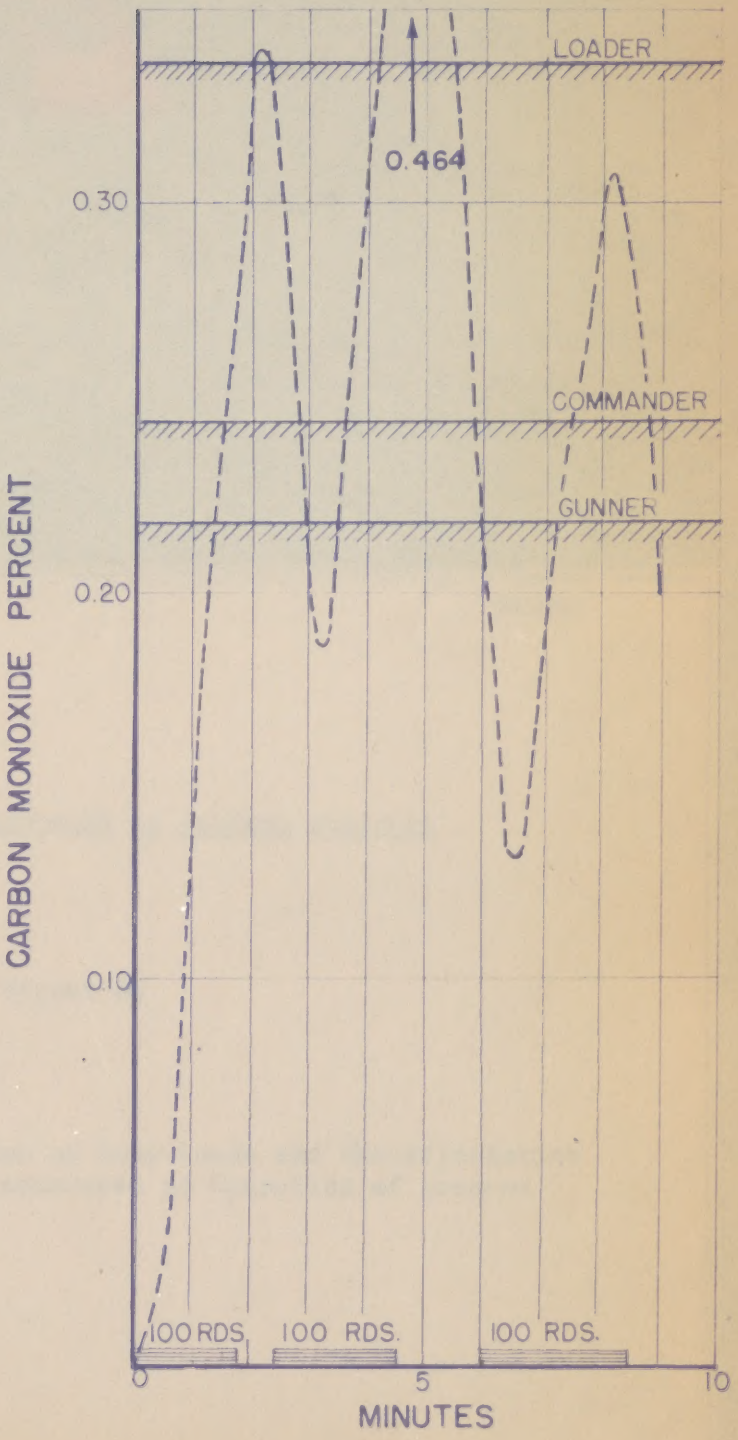

FIG. 1

FIG. 2

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